Heating of bilateral hip prostheses in a human body model induced by a multi-axis gradient coil set

Hector Sanchez-Lopez1, Luca Zilberti2, Oriano Bottauscio2, Jeffrey Hand3, Annie Papadaki1, Fangfang Tang1, Mario Chiampi4, and Stuart Crozier1

1School of Information Technology & Electrical Engineering, The University of Queensland, Brisbane, QLD, Australia, 2Istituto Nazionale di Ricerca Metrologica, Torino, Torino, Italy, 3Centre for the Developing Brain, Kings College London, London, United Kingdom, 4Division of Imaging Sciences and Biomedical Engineering, Kings College London, London, United Kingdom. 5Neuroimaging Analysis Centre, University College London Hospitals, London, United Kingdom.

Discussions and Conclusions: Figures a), b), e) and f) demonstrate that there is a strong dependency of the patient/implant positioning with respect to the individual gradient coil axes. The x-coil produces nearly four times more temperature increase than that produced by the y-coil due to the model positioning. Due to the enclosed structure of the z-coil the temperature increment is slightly larger than that produced by the x-coil. It is also noticeable that in one of the implants, the temperature rises slightly more than in other one, possibly due to small differences in the positions of the prosthesis stems within the femurs. In typical current sequences such as fat-sat or 3D-True-FISP, all three gradients are used intensively and therefore the temperature rise under these conditions is of concern. Temperature increments up to 1.7 times larger than those produced by the x-coil are predicted for the combined gradient fields (figures d) and h)). The results also demonstrate that the temperature increase associated with Ti6Al4V prostheses is smaller than that for CoCrMo prostheses.

This preliminary study is of importance as it contributes to the understanding of the gradient coil–implant interactions and the concomitant temperature rises. The modified phantom model together with powerful electromagnetic software provides a virtual testing lab capable of investigating flexible scenarios to answer diverse research questions such as: Can we modify the gradient coils to minimize the inductive coupling with the hip implant? What is the optimal material to produce a hip implant that is tissue compatible, light, and strong and at the same time minimizes the induced currents? How could we tailor the gradient pulse sequences to control the temperature increases? How much temperature increase is produced in split gradient coils? We anticipate answering these research questions in an extended study.

References